FINAL REPORT

CHESAPEAKE DIAMONDBACK TERRAPIN INVESTIGATIONS

FOR THE PERIOD 1987, 1988, and 1989

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INTRODUCTION

The diamondback terrapin, *Malaclemys terrapin*, has a long and rich history as a Maryland resource and mascot. Although this reptile once held great commercial value and was heavily fished in the 1920's, its exploitation has decreased since the 1930's. An active and modestly regulated terrapin fishery remains today; however, management has been problematic because of a poor understanding of the terrapin's biology. This species has been over-exploited in the past, as characteristics of its life history make it extremely vulnerable to over-harvesting and mismanagement. It is important, therefore, that contemporary management strategies are based upon a sound understanding of the terrapin's ecology and population dynamics. This report provides preliminary demographic data of a population of terrapins which has been under continuous study since 1987.

This research is part of a long-term effort dedicated to understanding the ecology, life history, behavior, population dynamics, habitat requirements, and stock assessment of the diamondback terrapin. These data can be used to evaluate current management regulations for the species in Maryland waters, and also will be the basis for an appropriate Chesapeake Bay-wide management strategy. The overall effort will be consistent with two living resources programs in the Chesapeake Bay restoration effort: 1) the evolving Cooperative Chesapeake Stock Assessment Program, and 2) the development of a Chesapeake Bay Key Living Resources Habitat
Requirements and Users Manual. These programs will identify the terrapin as an important organism in the Bay and the need for regulating its fishery and critical habitats.

This report has been divided into three chapters which describe the three major portions of this study. Chapter one presents demographic information. The second chapter provides a market analysis of the existing terrapin fishery in Maryland and determines the commercial potential of the species. The third study goal was to compile an annotated bibliography of the literature concerning diamondback terrapins which is given in chapter three. Finally, a general discussion is included to provide recommendations for the development of a sound management strategy.
CHAPTER ONE

DEMOGRAPHY AND NATURAL HISTORY
OF THE DIAMONDBACK TERRAPIN

INTRODUCTION

This section describes the natural history and known demographics of a population of diamondback terrapins which has been under study since 1987. Results reported herein were obtained through an intensive mark-recapture study of a population of terrapins in a segment of the Patuxent Estuary. We caution the reader that the results reported here are preliminary because of the longevity of turtles and the limitations of our techniques and abilities to study these animals.

Demographic studies attempt to determine age and sex structure, recruitment, and losses within a population by studying the four basic processes which affect populations: birth, death, emigration, and immigration. Our work over the last three years has involved intensive effort to capture as many of the individuals within the Patuxent population, mark them, and then release them and later recapture them.
METHODOLOGY

Study Site:

The study site lies on the western shore of the Patuxent Estuary and ranges south from Spring Cove north to Long Point (Figure 1). During the 1987 field season capture efforts were restricted to the area between Spring Cove and Cremona Creek. In 1988 efforts expanded to include captures up to Washington Creek; in 1989 efforts included Trent Hall Creek. Figure 2 illustrates the sites at which traps have been placed over the last three years.

Several nesting beaches are located on the study site; only two of these were monitored for nesting activity. These were Burton's Beach and Marsh Point Beach (Figure 1). Marsh Point Beach is a narrow (10 m wide) sandy strip which faces southeast and is bordered by a salt marsh. Nesting activity is restricted to this sandy strip. Burton's Beach faces northeast and is bordered by agricultural land. Turtles nest primarily on the sandy portion of the beach, although some turtles have been found after nesting in the agricultural fields. Unfortunately, we have been unsuccessful in locating these field-laid nests. The accumulation of soil on the shell of turtles found in these fields, in addition to a dilated cloaca indicate that nesting did occur in these areas. Both beaches have a transition zone which consists of open beach grading into sparse stands of *Spartina alterniflora*, and then to dense grass mats with marsh elder, *Iva frutescens*, interspersed. Terrapins tend to nest in the zone with
little or no vegetation.

Mark-recapture:

Mark-recapture techniques were employed to determine population structure and to follow individual movement patterns. Terrapins were marked by notching or drilling the marginal scutes. Several techniques were used to capture terrapins. These techniques include fyke nets, peeler bank traps, drift fences, and the capture of turtles by hand as they came ashore to nest. During the 1987 to 1989 period, we had 2989 captures of 2052 turtles with 886 recaptures of marked individuals, and 51 dead turtles. Upon capture, straight line measurements were taken of the plastron, carapace, and right pectoral scute. Turtles were then weighed, examined for marks or marked if it was the first capture of the animal, and aged by counting annuli on the plastron if possible. Mature females were checked for the presence or absence of eggs by inguinal palpitation. Turtles were then released at site of capture within 24 hours.

We have invested a considerable effort in the capture of females during the nesting season. This makes it possible to associate females with their nests, thus providing data to determine the reproductive output of nesting females. Two beaches were monitored for presence of nesting females, and additional nests which could not be associated with a particular female were also monitored. During the three year period, we obtained data from 1022 nests, 189 of which could be associated with the female that produced the clutch. We have
consistently found the same number of nests every year, however an increased effort has led to a larger proportion of nests for which the female is known. These nests were excavated to count and weigh the clutch, and to measure the depth to the top and the bottom of the nest. Our conclusions concerning the nesting and reproductive biology of terrapins are based on these data from 189 nests.

Statistical techniques used to analyze data are described in the results and their interpretation. Data were analyzed using the Statistical Analysis System and dBase III-plus programs. Graphics were completed using SigmaPlot. Because of the variety of data included in this report, results and conclusions have been combined in order to avoid confusing the reader.

RESULTS AND DISCUSSION

Population Size and Structure:

A Jolly-Seber population estimate was calculated to determine the size of the population under study. The Jolly-Seber technique is best suited to open populations where immigration and emigration occur. This technique also requires discrete sampling periods; here, year was the interval chosen. The estimate of the population, using three years of data, was 2293 individuals, with a 95% confidence interval from 1717 to 2895. Caution should be taken, however, because three sampling periods is the minimum number of samples for which this type of estimate can be used. The estimate of population size should
improve in subsequent years, as additional sampling periods are added to the data set. The Jolly-Seber (Jolly 1965) estimate can also be affected by unequal sampling effort; also, the continuous expansion of the study site over the last three years may have biased our estimate. Additionally, our lack of sampling on the eastern shore of the Patuxent may have an effect on the population estimate. In future years we plan to sample this and other areas downriver of the study site.

Age structure of the population under study is provided in Figure 3. There are several important points to note concerning these data. The first is that there is variation in recruitment from year to year. This variation is reflected in the number of both juveniles and older individuals in the population. Most of the juveniles are individuals caught as hatchlings emerging from nests on the nesting beaches. We have caught a single two-year-old during the study, while three- and four-year-olds were commonly caught in our traps. The second point is the bias in sex ratio of adults, which is 2.25:1 female-biased. The third result given indicates a variation in sex ratio from year to year. For example, 1984 has a male-biased sex ratio, however 1983 and 1985 have female-biased sex ratios, while 1981 appears to have a one-to-one sex ratio. These results may represent variation within this population, however a sampling bias cannot be ruled out. Additional data is necessary to correlate the incubation period's climate with the observed variation in sex ratio. The lack of individuals in cohorts 1980 reflects our inability to age animals greater than
approximately 7 years of age and not that these cohorts are missing from the population.

We have identified several sources of adult mortality, including crab pots, motor boats, and raccoons. Additionally, raccoons, foxes, and otters have been identified by their tracks as predators of eggs. Probably the major source of mortality for terrapins in the bay area are crab pots which are fished from private piers, but which are not checked daily or are abandoned. We found one such crab pot which contained 49 entire terrapins and the skeletal remains of others (Figure 4). Additionally, terrapins were commonly found floating or washed-up on shore which were suspect of having drowned in fishing gear. The terrapins caught in crab traps are usually males and juvenile females. Crab pots may constitute a considerable source of mortality on a Bay-wide basis in those rivers and creeks where terrapins are found. Mature females are too large to enter the crab pots. Motor boats, however, are a major source of mortality for mature females. We have found 26 terrapins which have died as a result of damage to their shell from boat propellers over the last three years. In addition, 5% of the population bear the scars of encounters with boats. We have found one juvenile terrapin which was killed by a raccoon.

The largest source of mortality for terrapins occurs during the egg stage of the life cycle. Raccoons and foxes are extremely efficient predators on turtle eggs and destroy approximately 95% of
the nests on the two beaches observed. This predation usually occurs within the first 24 hours of laying the nest (Figure 5). Other factors also contribute to the demise of turtle nests on the beaches. Grasses have been observed to destroy nests as the rhizomes penetrate and destroy the eggs. Another factor in egg mortality is periodic high tides, which occasionally drown embryos in the nest if the eggs remain submerged for prolonged periods of time. These factors all play a role in nest survivorship. During the three study years tracking nest survivorship we estimate that between 1 and 3% of the eggs laid on a nesting beach actually produce hatchlings.

Survivorship of juvenile cohorts has not been determined. This failure is partly due to an inability to catch two year-old individuals coupled with low capture rate of three year-olds. Thus little data are available on hatchling cohorts which we have marked in the past three years. Additionally, the variation in recruitment from year to year may produce large errors when horizontal estimates of survivorship are made. Efforts will continue to determine juvenile survivorship through continued sampling efforts as marked hatchlings approach capturable sizes and by sampling new areas by techniques described by Pilter (1985).

Terrapins are sexually size-dimorphic (Figure 6). This size dimorphism is independent of age, and thus is not due to differential survivorship between sexes. This figure also provides a growth curve for the two sexes and illustrates the difference in size at maturity.
This separation is due partially to a difference in age at maturity between the sexes: males mature between four and six years of age while females mature between nine and thirteen years of age. It is possible that the bias in sex ratio in adult terrapins (Figure 3) noted above may be a result of differential survivorship between males and females in which females live longer and are thus over-represented in the sex ratio. Differing ages of maturity may also affect survivorship; since males mature at earlier ages they may also senesce and die younger.

Finally, the mark-recapture data has provided much information about movement patterns of terrapins (Figures 7, 8, and 9). These data indicate that there is considerable variation among individuals in their movement patterns. Females appear to move considerable distances, but this result may be somewhat misleading. The captures of females on the nesting beaches in 1989 showed that 92% of the turtles captured had been marked in previous years, indicating that although terrapins may move considerable distances for foraging or other reasons, nesting activity may be restricted to particular beaches for certain females. Although our capture of males indicates less movement, this probably reflects a sampling bias. The recapture rate of females is much higher because trapping efforts are restricted to near-shore shallow areas, while males seem to be more pelagic since they have no need to come ashore. Juvenile movement patterns also indicate considerable movement. Their movement pattern is likely to be indicative of a foraging strategy which involves a constant search.
for food. It is likely that juveniles remain in an area as long as foraging is possible, but as food becomes limiting, their search for more food may result in dispersal.

Nesting Behavior and Ecology:

Terrapins in the study population begin nesting on or about the first of June and continue late into July. Summary statistics of terrapin reproductive output is given in table 1. A terrapin may nest as many as three times in a single nesting season with an average interclutch interval of 15 days (Figure 10). Circumstantial evidence, based on the interclutch interval data and frequency of nesting of some females, suggests that a fourth nesting may be possible, though there is no clear evidence for this. An attempt was made to determine a relationship between female size and various measures of clutch size, including the number of eggs in the clutch and their total mass, to explain the observed variation in clutches, but no significant relationship was found. A regression of plastron length on the number of eggs in a clutch is not significant (\( P > 0.05 \), Figure 11). Similar results were obtained when total clutch mass and relative clutch mass were analyzed. Because terrapins produce several clutches, an analysis for a relationship between measures of repeated nesting events by individuals was made to determine a possible cost of producing additional clutches. No consistent relationship between first and subsequent clutches was found (Figures 12 and 13). Thus it appears that terrapins have the ability to consistently produce clutches throughout the season with no decrease in investment in the
clutch.

Presently, not enough data are available to determine fecundity schedules for the population under study. This determination is one of the primary objectives of a demographic study and is necessary to construct an accurate life table. Terrapins can no longer be aged after reaching about seven years; however, they become reproductive between their 9th and 13th years. Thus, there is no useful information on age-specific fecundity rates, especially for older individuals. The program will continue to attain information of fecundity schedules as known aged females begin the reproductive stage of their life cycle.

Environmental sex determination has been investigated, and it was conclusively demonstrated that temperature influences sexual differentiation in this population (Roosenburg and Kelley in prep.). This laboratory study has demonstrated that cooler temperatures (26 C) produce males and that warmer temperatures (32 C) produced females. These investigations have continued through field experiments by attempting to determine how variation in weather patterns affects survivorship and sexual differentiation. The program has characterized the beach nesting environments by the amount of vegetation and number of hours of direct sunlight that a nesting area receives. Microhabitats of nests were then categorized according to these criteria. Nesting by females is heavily biased toward open and sunny locations (Figure 14). The placement of nests in these
locations resulted in mostly male turtles during the 1989 nesting season, 62 of 63 hatchlings produced. This probably was because of the cooler then normal temperatures which occurred during 1989. It is likely that female turtles selected the open, warmer areas because these areas maintain the maximum likelihood for the successful development of the nest and that sex determination is just a function of the ensuing environmental conditions.

It is possible that those environmental factors which influence sex determination, such as temperature and rainfall, vary from year to year. Thus, skewed primary sex ratios may be the product of variation in environmental factors. This hypothesis is supported by the result in Figure 3 which illustrates differential recruitment to the sexes in different years. We cannot be certain, however, that these data are the result of variation in climate, because we cannot account for differential survivorship the sexes in the younger cohorts. Nevertheless, these data are consistent with the environmental variation hypothesis. To gain a better understanding of variation in climatic conditions which effect the incubating embryos, investigations of sex determination and nest survivorship are continuing. By recording nest temperature under differing experimental conditions, we plan to compare the sex ratio of these nests with those of natural nests from nesting beaches. Additionally, a correlative study will investigate the variation in sex ratio with variation in weather conditions to support the environmental variation hypothesis.
FIGURE LEGEND

Figure 1. Map of the Patuxent Estuary study area.
Figure 2. Map of trapping sites in the study area. Arrows indicate trap locations.
Figure 3. Age structure of the population under study based on the original capture of all individuals caught over the three year period. Solid bars represent juveniles (sex not determinable), open bars represent males, and crosshatched bars represent females. Individuals which were too old to be aged are in the "no age" category. 861 is the total number of "no age" females.
Figure 4. Photograph of a crab pot with dead terrapins inside. 49 whole terrapins plus skeletal remains of others were removed from this trap.
Figure 5. Graph illustrating the days to predation of nests on Burton's and Marsh Point Beach for 1987 and 1988.
Figure 6. Graph illustrating sexual dimorphism of individuals in the study population. Squares represent males, circles represent females, and triangles represent juveniles. Error bars show two standard errors.
Figure 7. Map indicating the capture sites of three different females over the three year period.
Figure 8. Map showing the capture sites of three different males over the three year period.
Figure 9. Map showing the capture sites of three different juveniles over the three year period.
Figure 10. Graph illustrating the interclutch interval of individual terrapins which were captured during more than one nesting event in a single season.

Figure 11. Regression of log transformed clutch size (number of eggs in clutch) on log transformed plastron length of the female producing the clutch. Eleven percent of the variation is explained by this relationship and the regression is not significant.

Figure 12. Plot showing the relationship between clutch size and date of the nesting for 1988 and 1989. Lines connect the clutches of the same individual. Squares represent double clutches and triangles represent triple clutches.

Figure 13. Plot showing the relationship between clutch mass and date of the nesting for 1988 and 1989. Lines connect the clutches of the same individual. Squares represent double clutches and triangles represent triple clutches.

Figure 14. Graph showing the frequency of nests in different microhabitats on Burton's and Marsh Point Beach for 1987 and 1988.
Figure 5

1987

- BURTON'S BEACH
- MARSH POINT

FREQUENCY

DAYS TO PREDATION

1988

- BURTON'S BEACH
- MARSH POINT

FREQUENCY

Figure 5
$y = 1.987x - 7.909$

$r^2 = 0.1144$
BURTON'S BEACH

MARSH POINT

Figure 14
| **TABLE I** |
| **SUMMARY STATISTICS OF REPRODUCTIVE BEHAVIOR** |
| **MEAN** | **MINIMUM** | **MAXIMUM** |
| CLUTCH SIZE | 12.75 | 1 | 21 |
| CLUTCH MASS (g) | 135.59 | 6 | 208 |
| RELATIVE CLUTCH MASS | 0.087 | 0.006 | 0.160 |
| FEMALE PLASTRON LENGTH (mm) | 191.95 | 173 | 216 |
| FEMALE MASS (g) | 1538.85 | 1180 | 2000 |
| NEST DEPTH (cm) | | | |
| TOP | 10.8 | 5.5 | 15.0 |
| BOTTOM | 16.7 | 13.0 | 21.0 |
LITERATURE CITED


CHAPTER TWO

MARKET ANALYSIS

OF THE

DIAMONDBACK TERRAPIN FISHERY AND COMMERCE

IN MARYLAND

ABSTRACT

The diamondback terrapin, *Malaclemys terrapin*, is a valuable ecological and economic natural resource, having social value as a mascot within the state. During the early 1900's a large fishery was based on this turtle in Maryland waters. The delicacy of its meat was famed throughout major cities on the Atlantic coast, and for this reason terrapins sold for high prices. However, the "boom" in the terrapin industry collapsed due to several factors. These include the beginning of the depression, the prohibition of alcohol, and the gradual decline of terrapin populations throughout their range. At present, there is a small trade in terrapin, however the demand for this turtle is likely to increase in the future because of a growing popularity for its flesh among Amer-asians. The present fishery probably nets between $20,000 and $30,000 a year, at a price range from $2.50 to $6.00 per terrapin. We estimate that this represents an annual harvest of 8,000 to 12,000 individuals per year. Understanding
of the population levels in the Bay is not sufficient to determine what effect this harvest mortality has on the overall population, but extensive fishing in localized areas may result in severe reductions in the brood stocks of certain populations.

This chapter describes the Maryland terrapin fishery. It documents the history of the terrapin trade and summarizes the current commercial activity based on a survey of seafood wholesalers and distributors. The report also makes recommendations for improving the database of Maryland's terrapin industry and suggests new regulations based on knowledge of terrapin biology and current laws which govern the fishery. The most important and urgent recommendations are:

1) to protect the terrapin for a period of the year which includes its nesting season as has been done by other states in which terrapins can reproduce undisturbed;
2) to provide a species code for terrapin on the monthly Fisheries Statistic Report form along with a letter informing watermen that a species code now exists for terrapins and that they should be reported and no longer considered by-catch;
3) to change the current size restrictions of terrapins so that the harvest is not biased toward reproductively active females, or place an upper limit on the size to protect some of the reproductive females, such as eight inches along the bottom shell; and
4) to require a specific license to harvest terrapin, at no additional cost to Tidal Fish License holders, indicating a clear intent to fish terrapin and not exploit it as a by-catch.
HISTORICAL BACKGROUND

The early history of the development of terrapin as a culinary delicacy is not well known. The first reference to terrapin consumption indicates that during the 18th and 19th century slaves were fed terrapin as a source of protein (Coker 1920). Some masters found terrapin meat so readily available and inexpensive that they forced slaves to eat it almost exclusively; this limited diet encouraged the slaves to demand better conditions (Coker 1920, Carr 1957, Lawson 1988). The strike by slaves was so widespread that the first reported legislation concerning terrapins in Maryland ruled that slaves could be fed terrapin no more than twice a week (Coker 1920, Lawson 1988).

It is unclear when the terrapin trade began that eventually decimated populations throughout the east coast. In its early stages, the market for terrapin soup was developed in part by Albert LaVallette who established a vast fishery of terrapin in Crisfield, Maryland (Lawson 1988). As an entrepreneur he fostered an interest in terrapin by shipping them to cities throughout the northeast, where they sold as a delicacy. As the demand for terrapin increased so did the fishery; when the price of terrapin increased watermen turned to fishing terrapin because of the greater financial rewards in comparison to crabbing and oystering. By the 1920's terrapin had become so scarce that the price soared to an unbelievable $120 per
dozen in some areas. At that same time a bushel of oysters brought less than one dollar.

By the early 1900's the demand for terrapin meat was so great and its cost so high that the United States Bureau of Fisheries established two large projects to investigate the feasibility of artificial propagation and the development of hybrid strains which might reach market size at earlier ages. These investigations were located in Lloyds, Maryland and Beaufort, North Carolina. The project in Maryland was abandoned after a few years, whereas the one in North Carolina continued through the next three decades. The latter study also was abandoned, after the demand for terrapin meat diminished.

The decimation of populations along the east coast began in Cape Cod, Long Island Sound, and Delaware Bay (Coker 1920). Terrapins from these areas were favored initially because of their larger size and apparent superior flavor over southern varieties. As the stocks in these regions were depleted, the main source of terrapin became the Chesapeake Bay. Known in the trade as "Chesapeakes", these too were valued for their large size and superior flavor. "Chesapeakes" also brought a high price, sometimes selling for as much as $120 - $140 per dozen; with this incentive for harvest, populations in the Bay declined rapidly. Maryland's terrapin trade reached an apex in 1891 when over 89,000 pounds of terrapin were sold, but by 1920 the resource was so depleted that watermen were able to bring a meager 829 pounds to market (Garber 1990).
In October of 1929 the Maryland Assembly passed legislation which prohibited terrapin capture from May through September and established a minimum harvest size of 5 inches along the bottom shell. These restrictions were taken to protect terrapins on their nesting beaches. Soon thereafter, the economic depression and alcohol prohibition brought the demise of the terrapin fad. With terrapins almost exterminated, the cost to obtain the meat was too great to pay and an essential ingredient of the soup, sherry, became illegal. Terrapin soup is still available in a limited number of restaurants throughout the state, but no longer has the popularity that it had at the beginning of the century.

CURRENT FISHERY AND MARKET

The information contained in this report was collected in a telephone survey of the seafood wholesalers, distributors, and watermen that trade terrapins in the Chesapeake Bay area. The questionnaires contained in Appendix I of this report were used in the survey as a guide to our interviews.

METHODOLOGY

Wholesalers and retailers mentioned in the "List of Maryland Seafood Packers", which was prepared by the Maryland Department of
Agriculture, Office of Seafood Marketing, were contacted by phone and asked to respond to a series of questions (see Appendix I for specific questions). All businesses listing terrapin as a market item were contacted; several businesses which did not list terrapin were also contacted. If the business said they did not handle terrapin, then they were asked if they knew any buyers or fishermen in their area that did. Any additional businesses were later contacted. Finally, in addition to collecting information about terrapins, we also asked questions concerning the snapping turtle trade.

We also attempted to locate and question watermen who fish for terrapin, but we were able to learn of only one waterman who consistently fishes for them. The series of questions which were used to interview this waterman is given in Appendix 1.

RESULTS

The list of Maryland Seafood Packers identifies seven businesses which handle terrapin. Two of these companies no longer exist, two have not sold turtles in the last five years, and three deal in snapping turtles but not in terrapins. An additional 51 businesses were contacted which did not list terrapin as a product or which were identified by the other businesses contacted. Of these, five companies said that they bought and sold terrapin; three mentioned that they have traded snapping turtles recently.
Our attempts to determine the number of terrapins sold in Maryland each year was met with limited success because of the variety of ways in which the catch is measured and recorded. One company, Kool Ice Seafood, reported that it bought approximately 2000 terrapins in the last year; another, Tidewater Express, reported shipping about 100 bushels to New York (there are 15 - 20 terrapins in a bushel depending on the size of the individuals, thus an estimate for this firm's trade is 1750 terrapins). Most of the other firms reported buying less than ten each year. There are a few companies which handle about 100 terrapins a year as a special favor to customers, or as a courtesy to the watermen who bring other more valuable seafood products. The most frequent response from the businesses surveyed to questions about terrapins was "Hell, I think I sold two all last year" or "I ain't seen one for years". We spoke with one waterman who ships his catch directly to markets outside of the state. He was hesitant to tell of his total annual catch. It is likely that there are other watermen of which we were unaware who fish terrapin under the Tidal Fish License and ship their catch out of state. We feel that a conservative estimate for the terrapin catch in Maryland is between 8,000 and 12,000 individuals a year.

Terrapin price varies. Kool Ice Seafood in Cambridge handles the largest number of terrapin in the state, approximately 2000 animals a year. It buys terrapin from watermen for $2.50 apiece, then sells them for $3.50. Prices quoted by other businesses vary depending on the customer and number of handlers from the waterman to the final
customer. The highest prices reported among these merchants were between $2.50 - $4.50 per turtle when purchased from the waterman, and a price of $6.75 to the final customer. All of the firms interviewed reported that their terrapin trade was less than 1% of their total business. One waterman with whom we spoke said that he had to find his own market with out-of-state buyers in order to make the business profitable; he usually receives between $4.00 and $6.00 per terrapin. With these figures we estimate that terrapin trade in the Maryland involves between $20,000 to $30,000 annually.

Wholesalers identified four techniques used by watermen to catch terrapins. The first technique uses a scrape, similar to a dredge, which is designed to dig turtles out of the mud while they are hibernating. A second involves using a dip net to dig them from the mud. In this technique, the waterman goes out at low tide on a calm day when the water is clear. He then looks for "sign of turtle": a small (1' - 2') depression on the bottom. When he locates the animal, he uses the net to dig the terrapin out of the depression; sometimes catching several terrapins in a single depression. Watermen use these techniques during the winter months and can be rather successful. One waterman we interviewed claimed that he had caught 365 terrapins in one day. He also mentioned that certain habitats can sometimes yield substantial numbers of terrapins and told us about one particular area which had produced almost 700 turtles in a few days.

Additionally, some terrapin are caught incidentally using
techniques designed to harvest other commercial species in the Bay. These techniques include the use of fyke nets and bank traps. Usually when terrapins are caught in this manner, they are retained in addition to the primary catch and sold to "help pay the gas". This by-catch occurs most often during the spring and summer, when fish and crabs migrate in the Bay. According to our survey approximately 30 watermen bring their terrapin to market in Maryland using one or more of these methods. There may be other fishermen who sell "by-catch" terrapins since many of the terrapins caught are sold outside the state. Terrapins are all bought and sold live and are sold live to the final consumer.

Terrapins are harvested throughout the Bay, however fishing pressure on populations is probably heaviest in areas where there is a readily available market for those watermen who desire to sell their incidental catch of terrapin. This occurs especially in the Cambridge and Crisfield areas (Figure 1). Kool Ice Seafood of Cambridge does a large trade in other commercial species and, as a courtesy to their watermen, the business buys the terrapin catch. Most of these terrapins are incidental captures in fyke nets during spring fish runs. In the Crisfield area we were not able to find a major buyer of terrapin, although we were able to identify a trucking company which frequently ships terrapins to New York and other cities to the north. This paucity of terrapin wholesale purchasers in Maryland is probably the reason why some watermen develop their own contacts with purchasers out-of-state.
The ultimate destination of terrapins varies, although few remain in the state to be used in restaurants or in the home. The majority of terrapins are shipped to urban areas in the northeast, primarily to New York. Several of the firms which sell terrapins out-of-state reported that the turtles are popular among Asians, who use the meat for specialty dishes. New York's Fulton Market is reported to sell over 10,000 terrapins a year (Garber 1990). This ethnic market seems to be increasing, and some watermen apparently sell terrapin to them directly. When asked if they would like to see an increase in the amount of terrapin traded, most retailers in the Maryland seafood industry responded they would be pleased to see this, but mentioned that at the present time there is not enough demand to increase the terrapin commerce.

We also requested that merchants provide information of their business concerning snapping turtles within Maryland. We can account for the sale of 45,000 lbs each year. We wish to emphasize that this may be a gross underestimate of the total trade of snappers both because our survey concentrated on terrapins and because a large number of snappers are caught for personal consumption. Watermen sell live snapping turtle for $0.40 - $0.75 a pound; they are then sold by suppliers for $0.60 - $1.00 a pound. Most retailers said that snapping turtles accounted for less than 1% of their total business, with the exception of one firm in Rock Hall, Maryland, Hubbard's Seafood, which estimated that about ten percent of their business is in snapping turtles.
To catch snappers, turtle pots or traps are most commonly used; these hoop traps, which resemble the cod-end of a fyke net, are usually baited with fish. Snapping turtles are caught from tidal headwaters of the rivers and creeks within the Bay, as well as from farm ponds and freshwater ponds and lakes. Snapping turtles caught in Maryland are usually sold to processing plants, such as Century Seafood in Philadelphia, where they are cleaned, frozen, and then sold to restaurants in the northeast. Processing involves removing the head, limbs, plastron, and entrails, then packing the meat in the carapace. The snapping turtle industry seems to maintain a steady business, with a limited but consistent demand.

DISCUSSION

The analysis of the terrapin industry in Maryland is problematic, as discussed below, and a survey of the seafood wholesalers in the state cannot fully describe this fishery. There are two reason why this survey might be incomplete. First, since the diamondback terrapin is not considered a primary commercial species by many firms, they claim that they do not keep accurate records on the sales and target market of terrapins. Second, those watermen that intentionally catch terrapin find the best prices with out-of-state wholesalers or sell directly to local retailers. Apparently, no record is made of these out-of-state and direct transactions. Our survey accounts for a minimum 4000 terrapins caught in Maryland waters per year. We feel
that this is a conservative estimate and the actual catch probably ranges from 8,000 to 12,000.

There is opportunity for increased future trade of terrapins. Currently the largest market for terrapin is among Asians. These buyers are beginning to pay higher prices for terrapin, e.g. $4.00 - $6.00 each; this is a strong incentive for watermen to pursue the species. Expansion of the market, coupled with the limited availability of other commercial species, is likely to increase the capture of Maryland's terrapins. A small portion of the collected terrapins remains within the state and a few restaurants still prepare terrapin stew, including the Tidewater Inn in Easton, Maryland. Wholesalers which provide terrapin to restaurants trade "on demand" only. Surprisingly, one wholesaler, Belvedere Seafood, based in Maryland, has flown terrapins from Louisiana to sell them locally, in the Baltimore area, and to markets in New York and Philadelphia. Currently, few seafood buyers in the state are willing to handle terrapins, thus forcing watermen to develop their own market out-of-state. The one waterman with whom we spoke, Dwight Marshall, said that he sells terrapin to Fulton Market in New York City and has even investigated a market in California. As the popularity of terrapin grows, the distance of shipment of the meat is likely to increase.

Dwight Marshall fishes specifically for terrapin during winter months to supplement his income, which has dwindled in recent years with the declining oyster fishery. Although many individuals may fish
specifically for terrapin, few of these watermen are consistently successful. The practice requires a thorough knowledge of the habits of the animal and an ability to detect the terrapins' presence. A lack of this specialized knowledge, along with the need to find their own market, probably discourages many watermen from fishing the species. Nevertheless, a knowledgeable and successful fisherman can supplement his winter income considerably.

The most alarming feature of the terrapin fishery in Maryland is that the minimum size requirement biases the catch almost exclusively toward female terrapins which are reproductively mature. The restriction of a six inch measurement of the bottom shell is rarely exceeded by males; in the demographic study (described in another chapter) we have never caught male terrapins this large. In contrast, the waterman with whom we spoke claimed that he did send some terrapins to market which were "bulls" (males), but was not paid for them because they were not "heifers" (females). From a management standpoint, harvesting only females of reproductive age puts the terrapin in a dangerous situation. Harvesting only the females of an animal whose age at first reproduction is between nine and thirteen years and whose replacement rate to the hatchling stage is 1 in 100 eggs produced, requires that the mother lay more than 9 clutches to replace herself as a hatchling. With this kind of life history, it is important that the fishery of terrapin be monitored carefully since heavy fishing pressure could quickly extirpate local populations and cause rapid declines throughout the Bay. It is unfortunate that male
terrapins are not as desirable, otherwise a separate legal size for each sex would allow for the harvest of the smaller males. The harvest of males, however, remains problematic since the mortality due to crab pots on a Bay-wide basis is unknown and it may be premature to decrease the lower size limit until a better understanding of this source of mortality has been obtained.

Other states throughout the terrapin's range have implemented stricter regulations concerning the fishery of diamondbacks. Terrapins are protected in Massachusetts, Rhode Island, Alabama, and Mississippi. New York State has just implemented new restrictions on terrapins which closes the season from 1 May to 1 August to protect terrapins during their nesting season. They also imposed a size limit of a carapace length between 4 and 7 inches, thereby protecting a portion of the reproductive females. Perhaps the most restrictive state is New Jersey where terrapin fishing is permitted only from 1 November to 1 April. Delaware, South Carolina, and Georgia have laws which protect terrapins during the nesting season. Similar measures may be appropriate for Maryland.

In order to improve the reporting of terrapin captures by watermen and seafood buyers we propose the following protocol. The currently used monthly report form sent to watermen should be updated with a code to include the diamondback terrapin. This should be accompanied with a letter indicating to watermen that there has been a change and that terrapin should no longer be considered as by-catch

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which is not reported. Additionally, those watermen who check terrapin on the Tidal Fish License or buy a specific terrapin license should be requested to fill out catch reports. (This was recently implemented when it was discovered that terrapin fishermen were not being sent report forms.) The retail report forms includes terrapin, however reporting seems to be withheld. The only solution here involves enforcement of the catch reporting laws. The method of reporting terrapins should be standardized to the number of individuals caught. Marketable terrapins can weigh from 2 1/2 to 6 pounds which leaves a large margin of error in estimating number of individuals from total poundage. We offer to cooperate with DNR to develop such a program and establish an accurate reporting system.

Finally, the following are recommendations for new legislation of the terrapin trade. The state should institute a "winter only" fishing season to eliminate the trade of incidentally-captured terrapins during the summer months. During summer months, local female populations aggregate near nesting beaches and can be easily caught both in water and on land nesting. The use of permanent fishing devices such as peeler bank traps could quickly eliminate a high proportion of nesting populations. After three years in the current study, 95% of the turtles coming onto a particular beach to nest have already been marked; if we had been removing the terrapins as we caught them, most of the population would be gone. Permanent fishing devices could have the same effect, and thus could substantially reduce local populations. It is suggested that a
separate and specific license for any harvesting of terrapin be
established; this regulation also will reduce the pressure on
populations where individuals are caught incidentally. This license
should be independent of the Tidal Fish License (TFL) but should be
available at no cost to those who fish under a TFL.

In addition to discussing the terrapin trade, we have reported
some information on the trade of snapping turtles in the state.
Snapping turtles are also long-lived animals with late ages of first
reproduction, and thus may be subject to constraints similar to those
of terrapins, although our study does not investigate the life history
characteristics of snappers. It would not be unreasonable to assume
that they face similar if not more perilous situations, since the
fishery of this species appears to be larger and increasing.
Unfortunately, this animal's unappealing appearance and disposition
may be limiting to public interest in this species, which may be over-
fished already.
LITERATURE CITED


Figure 1. Map indicating the location of active terrapin shippers and buyers in the Bay region.
Figure 2. Map indicating the destinations of terrapins caught in Maryland waters of the Chesapeake Bay.
APPENDIX 1

WHOLESALE DATA SHEET

Name and address:

1) Do you buy and sell diamondback terrapins? ______
2) Do you buy and sell snapping turtles? ______
3) What are your purchase and selling prices for terrapins?
   Buy ______
   Sell ______
4) What are your purchase and selling prices for snapping turtles?
   Buy ______
   Sell ______
5) What percentage of your sales involves terrapins? ______
6) What percentage of your sales involve snapping turtles? ______
7) How many watermen do you buy terrapins from who fish for them regularly?
   _______  How many for snapping turtles? _______
8) How are the terrapins that you buy caught by watermen?
   How are the snapping turtles caught?
9) What part of the Bay do the terrapins that you buy come from?
   From where do the snapping turtles come?
10) Approximately how many terrapins do you sell in a year? _______
   snapping turtles _______

11) Do you process the turtles you buy in any fashion? _______
   What kind of processing do you do?

12) Who do you sell most of your terrapins to?

13) Do they go out of state? _______
   If yes, which states?

14) Would you like to increase your trade in turtles? _______
   Is it profitable trading turtles? _______

15) Have you ever noticed any marked turtles? _______
WATERMAN DATA SHEET

Name and address: (optional)

1) Do you fish for terrapin? ______________
2) Do you fish specifically for terrapins or catch them incidently? _____
3) When do you fish for terrapin? ______________
4) What methods do you use to catch them? __________
5) Where in the Bay do you fish for terrapin? Which areas?

6) Do you fish the same area continuously or do you move around?
   Over what range?

7) Have you noticed a decline in the recent years? _______
8) How many terrapins do you catch in a year? _______
9) Who do you sell them to?
10) How much do you get for them? _______
11) Has the price changed lately? _______
12) Do you hold terrapins until you have a sufficient number to sell? ______
     What do you hold them in?
13) Do you buy and hold terrapins for other watermen? ______
14) How long do you hold terrapins usually? ______
15) Do you feed them? ______
16) Can you tell the difference between male and female turtles? ______
17) Have you ever caught any male terrapins large enough to sell? ______
18) Have you ever noticed any marked terrapins? ______
19) Is it profitable for you to continue fishing terrapins in the future? ______
20) Can you make a living from just fishing for terrapins? ______
CHAPTER THREE

ANNOTATED BIBLIOGRAPHY

OF THE LITERATURE ON THE

DIAMONDBACK TERRAPIN, MALACLEMYS TERRAPIN

INTRODUCTION

This bibliography is an annotated list of the literature concerned with the diamondback terrapin, Malaclemys terrapin. The list has been divided into two categories so that users can expeditiously locate appropriate material for their interests and needs. The first category is "Scientific Papers", which represents original published research on various topics where terrapins were used as the study organism. Scientific papers published on terrapins address a wide variety of topics, including systematics, life history and reproductive biology, physiology, and natural history. The second topic is "Field Guides and Natural History" which lists terrapin publications on identification and natural history.

The diamondback terrapin was originally described by Schoepff in 1792 as Testudo terrapin, and has since gone through several revisions of both its common and scientific names. It is now called the diamondback terrapin, Malaclemys terrapin. Variations in nomenclature and spellings are reflected in the titles of articles listed below.
Information on early systematics of the genus can be obtained in Hay (1904).

Studies which investigated life history and reproductive biology of terrapins were conducted in the early 1900's, because of a great demand for terrapin meat. This was also a period of dwindling abundance of natural stocks. At this time several projects were undertaken in an attempt to maximize reproductive output and growth rates of captive terrapins. Recent studies of reproductive characteristics of terrapins have been conducted by both Burger and Seigel. Finally, a great number of papers have been published on the orbital salt glands of terrapins. Because terrapins are estuarine, they are subject to salt stress. This phenomenon has been of great interest to comparative physiologists such as Cowan and Gilles-Baillien. The remainder of publications consists of a variety of brief notes which describe natural history, range expansions, and other interesting observations.
SCIENTIFIC PAPERS


Eight hundred and seventy-five terrapins collected from a terrapin farm in North Carolina were brought into the lab and raised on a variety of diets. Terrapins preferred shellfish, when given a choice between shellfish and beef; however when raised exclusively on beef, individuals grew just as well as those fed shellfish. The only food which terrapins consistently refused to eat for prolonged periods of time was liver.


A brief account was given of the history of the diamondback terrapin as a delicacy. Included was a list of the four kinds of diamondback terrapins that inhabit Florida: the Southern diamondback terrapin, the mangrove terrapin, the Florida diamondback, and the Mississippi diamondback terrapin. Their feeding and nesting habits were mentioned. A description and picture were given of an oyster-encrusted turtle.


This article written for a general audience is a description of a continuing study of a population of diamondback terrapins in Sandy Neck, Massachusetts. The natural history of the population was described in detail, then compared and contrasted with that of a population of terrapins in New Jersey studied by Burger during the 1970's. The article described the methods used and some of the results of the Massachusetts study, including the mean monthly temperatures of terrapin nests. Finally, this paper made recommendations for the conservation of terrapins in this population which lives at the northern end of the species' range.


This is an account of a range extension by the terrapin north to Barnstable Harbor on Cape Cod, Massachusetts. A description of the species was provided and some comments were made about the economic potential of the species. It was noted that densities on Cape Cod area were too low to support a commercial fishery.

Barney's paper is part of a series of papers which described several interesting life history characters of terrapins raised on a government-supported turtle farm in Beaufort, North Carolina. This paper provided information on age of first reproduction, effective sex ratios, and reproductive schedules of female terrapins. A comparison was made between hatchlings which were raised under natural conditions and those fed through the winter in green houses. Terrapins reached age of first reproduction in 5 to 6 years, gradually increasing their reproductive output until a peak at the time of publication, 25 years into the study. Turtles were observed to produce clutches 4 to 5 times a year, with an average production of approximately 24 eggs per year. Optimal sex ratio was 1 male: 3 females; in lots with a greater female-biased sex ratio a decrease in fertility was noticed. This paper also made recommendations for raising terrapins for the mariculture industry.


Osmoregulation was studied in terrapins and its effects on body mass, O₂ consumption, and ion concentrations in the blood. As terrapins were exposed to higher concentrations of sea water they 1) decreased in mass, 2) increased O₂ consumption, i.e. metabolic rate, and 3) increased Na and K concentrations in the blood. Thus, terrapins can osmoregulate, while other species of turtles exposed to similar concentrations of sea water could not, and subsequently died. The ability to osmoregulate occurred with the cost of increased metabolic rate, however.


Bishop described the incidental capture of terrapins by crab pots in the Wando Estuary of South Carolina. An estimated 2853 terrapins were captured by commercial watermen per year; approximately 10% of the terrapins captured drowned, but it was suggested that this mortality did not affect the population adversely. The terrapins were released because the individuals caught in crab pots were not large enough for commercial sale. It was mentioned that the legal size of terrapins is restricted to reproductive females and that this may be extremely detrimental to population levels if harvesting levels once again approach those of the 1920's.

Biochemical and histochemical examination of the lachrymal gland of the terrapin indicated that this gland plays an active role in salt secretion. Terrapins acclimated to different concentrations of salt water excreted salt through the lachrymal gland by active transport, the latter indicated by the presence of ATPase in the mucus. Terrapins held in fresh water continued to secrete mucus from the lachrymal gland, however the concentration of ATPase decreased. This evidence supports the hypothesis of active transport of salt and the notion that there is a metabolic cost for terrapins associated with living in brackish water.


Temperatures were monitored in nests and in the soil adjacent to nests over the course of the nesting season. Nests from a north facing slope and a south facing slope were compared. Nests which were laid in June took less time to hatch than those laid in July; the later nests had lower mean nest temperatures. Nests on the north facing slope took longer to hatch and had a lower mean daily temperature than those on south facing slopes. A diel cycle in nest temperatures was observed, ranging from 2-9°C. Metabolic heat production was observed in terrapin nests, with temperatures being 2-12°C above surrounding soil temperatures. Caution should be taken in interpreting these results, however, because the methodology used was poor and the results have not been replicated by other researchers who study turtle nests in similar species.


Data were presented on emergence, predation, and survivorship of hatchlings from natural nests. Thirty-six percent of the nests were not destroyed by predators, 69% of the remaining eggs hatched, and 76% of the hatchlings emerged from the nest. Hatchling dispersal from nests was random with respect to compass direction on flat areas, however hatchlings did move toward the nearest vegetation. Hatchlings emerging from nests on inclines tended to move downhill; this was true for both natural and experimental observations. An experiment conducted showed a positive relationship between the righting response of hatchlings and the size of the residual yolk sacks. Premature hatchlings which cannot right themselves quickly are more vulnerable to predation, this illustrates the importance of complete development before emergence.


Factors were described which contribute to the success of
terrapin nests. Several factors were measured including hatchling size, egg size, length of incubation period, and position of the egg in the nest. Predators were the major source of mortality in this population. Raccoons, gulls, foxes, and crows destroyed 50-70% of the nests in the two years of the study, with predation rates highest at the end of the nesting season when hatchlings were emerging. Distance of the nest to vegetation was correlated with predation rate. Survivorship on this beach ranged from 0.46 to 0.17 for the two years of the study. A correlation matrix of characteristics of hatchlings, nests, and eggs was presented. This paper also had an interesting description of the nesting behavior of the terrapin.


This paper is a copy of a report to the New York department of conservation which listed the reasons why the diamondback terrapin should be protected in New York. Seven reasons were noted. They include: 1) the number of nesting females has decreased, 2) females are vulnerable to car traffic on beaches and roads adjoining nesting beaches, 3) available nesting habitat has decreased, 4) incidental capture in crab pots results in drowning, 5) increasing human activity on nesting beaches increases numbers of natural predators, 6) increases in herring gull populations increase predation on terrapin nests, 7) and motor boats cause injury to terrapins. In 1989 the New York legislature took action and placed restrictions on the harvesting of terrapins.


Nest site selection was studied in a population of terrapins on Little Beach Island, in Brigantine Wildlife refuge, New Jersey. Time of nesting, and slope of and distance from vegetation of nest site were monitored. Terrapins were found to nest during daylight hours between 700 and 1900. Timing of nesting was correlated with high tide. Reasons suggested for this were: 1) a reduced distance travelled to nesting beach (approximately 50 m) decreases risk to predation and desiccation, 2) nesting below high tide areas is prevented. An increase in nesting activity was observed following a rain, although no nesting was observed during rains. Terrapins nested in areas with an average slope of 7.1°, which was less then the average slope (11.7°) throughout the nesting area. No association was found between the type of vegetation and turtle nest, however most nests were laid within 20cm of vegetation. Open areas were avoided, probably because of the unstable nature of the sand in dune habitats.


Data were presented on the reproductive habits of captive
terrapins taken from a population in Louisiana. The data included laying dates, egg measurements, and hatchling sizes. Laying started in July and ended in late September. One interesting observation was that female terrapins divided single clutches into several different oviposition events. This separation may be an artifact of terrapins which were taken from wild populations and then frequently disturbed during nesting.


This effort was one of the first published studies of a natural terrapin population. Previous studies primarily described captive-bred populations of terrapins. Cagle described a population which may have been an intergrade between the subspecies Malaclemys terrapin pileata and M. t. littoralis. Data were presented on size, number of oocytes present in 2 females, and growth rates of 12 juveniles (based on measurable annuli on the plastron). These results were compared with those for a North Carolina captive population. It was found that growth rates were faster and age of sexual maturity occurred earlier for the Louisiana population than for previously studied populations.


Carr sought to resolve some of the taxonomic confusion about the diamondback terrapin. He provided evidence that the genus should not be divided into the two species, M. terrapin and M. pileata. Carr described characters which were used to separate the two species and suggested that the groups should considered subspecies of one species. A dichotomous key was provided which makes possible the classification of the five subspecies of Malaclemys terrapin.


This short note reported the capture of terrapins in crab pots on the Choptank River in Maryland. Terrapins were attracted to several kinds of bait including shad, salted eel, chicken, fish parts, and soft crab. Terrapins were observed near pilings and bridge abutments, and were docile and easily approachable.


This paper is a long treatise on the natural history of terrapins known in 1906, and described the initiation of long term studies in outh Beaufort, North Carolina and Lloyds, Maryland. Descriptive
details were given on life habits, methods of collecting, abundance, stomach contents, and hibernation. Details were given about reproduction and growth rates of captive terrapins. The first mention of destruction of terrapin eggs by vegetation was made here. The information in this paper is descriptive; no quantitative data are given. Several interesting photos of terrapins and of the enclosures used in mariculture are provided.


Coker described the natural history of the diamondback terrapin and reviewed some experiments conducted in terrapin farms in Beaufort, NC. It also described the commercial history of the species, detailing the exploitation of the species. Meat of terrapins from Delaware Bay were considered the most valuable; however, this resource was quickly reduced so that the favored terrapin became the "Chesapeake". With the coming of the war, and the beginning of prohibition, terrapin soup was no longer popular, primarily because its key ingredient was sherry.


Coker reviewed the natural and life history data that was known about terrapins at this time. The results presented here were obtained from the extensive research program established in the early 1900's at Beaufort, North Carolina. This research was a project supported by the U.S. Bureau of Fisheries to establish a mariculture industry of terrapins. Coker also reported on the demise of the terrapin industry brought on by the depression, prohibition, dwindling natural stocks, and finally World War II, after which the market never recovered.


A study of the gross morphology and histology of the orbital glands of several different species of turtles was conducted. Two glands exist in the orbital region, the Harderian gland and the lachrymal gland. It was found that the lachrymal gland in terrapins is larger, but that it has a cellular structure similar to salt glands found in other animals. It was also noted that gland size varied proportionately with the salt concentration of ambient water.


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A histological study of the orbital gland and the lachrymal gland of diamondbacks and other species of emydid turtles was conducted. The cellular structure of the orbital gland in terrapins has a different morphology from other tissues used in active transport, however the lachrymal gland morphology is similar to other glandular tissues capable of active transport. Thus it was hypothesized, based on morphology, that the lachrymal gland functions in osmoregulation in this species. Examination of the other stenohaline emydid species indicated that the lachrymal gland in these species does not function in osmoregulation.


Cowan investigated lachrymal gland function in salt secretion and how the salt water environment affects terrapins. Terrapins in 100% sea water lost weight during extended exposures and the relative weight of the lachrymal gland increased. Plasma sodium and osmotic pressure increased in sea water initially, and then remained stable. In an additional experiment turtles were injected with additional salt or distilled water. Those injected with salt increased cranial salt excretion, while those injected with fresh water had low sodium loss.


Nitrophenylphosphatase (NPPase) from the lachrymal gland of terrapin was found to have the same level of activity as those in the salt glands of birds. There was no difference in the K+ stimulated NPPase activity between terrapins acclimated to salt water or fresh water. Three possible explanations were offered for this result: 1) glandular function is unaffected by salinity, 2) the gland may serve different functions in different environments and uses K+ stimulated NPPase in both processes, and 3) the gland is involved in salt secretion and is inactive in fresh water, but remains highly predisposed to function because of the variable salinity environments in which terrapins are found.


Cowan investigated salt gland secretions of the salt gland of terrapins acclimated to different salt concentrations of sea water. Terrapins secreted an orbital gland secretion with a Na concentration greater than sea water. Terrapins lost weight when placed in full concentration sea water, but weight could be restored after 30 minutes when placed in less than 60% sea water, presumably by drinking water.
It was concluded that terrapins can successfully ion- and osmoregulate.


This study investigated the effect of different osmolarities of preservative buffers on salt gland tissue from turtles raised under differing concentrations of salt water. Salt glands were removed from terrapins and were then preserved using different osmolarity buffers. An effect was noticed from the buffer osmolarity and the salinity treatments on intracellular geometry. Thus it may be difficult to evaluate whether the previously observed differences of salt glands of terrapins raised at different salinities is an actual physiological response or an effect of the buffer.

Cunningham, Bert. 1939. Effect of temperature upon the developmental rate of the embryo of the diamond back terrapin (Malaclemys centrata Lat.) American Naturalist 73:381-384.

Cunningham conducted an experiment on the effects of temperature on the length of the incubation. Temperatures were not well controlled. It was found that high constant temperatures >85°C are lethal. At all other incubation temperatures hatchlings emerged between 60-68 days. The author concluded that there is little temperature-induced variation in developmental period in this species.


Water absorption of reptile eggs was described in this paper. Eggs from the diamondback terrapin and the fence lizard were collected and weighed at the beginning and the end of incubation. Water was absorbed by both lizard and terrapin eggs. Terrapin eggs increased in weight from 38 to 47% over the incubation period. Eggs of the fence lizard increased by more than 100%. However, the dry weights of eggs were lighter at the end of incubation, than at the beginning indicating that some solid materials were lost.


Cunningham investigated absorption of minerals by terrapin eggs. Mineral levels were compared for eggs raised in sterile conditions and those from natural nests. No differences in mineral salts were detected between the two groups. Thus all the minerals needed for development are provided in the egg.

This was an abstract, in Italian, of a study done on the lacrimal gland of terrapins exposed to fresh and salt water. Lacrimal glands from terrapins exposed to salt water had columnar epithelium cells along the ducts of the gland. This columnar structure was not present in the ducts of terrapins acclimated to fresh water. There also was a difference in the Mg-dependent ATPase activity between these two tissue types. These differences were considered to be a product of the salt-secreting function of the lacrimal gland.

Dobie, James L. and Dale R. Jackson. 1979. First fossil record for the diamondback terrapin, Malaclemys terrapin, (Emydidae), and comments on the fossil record of Chrysemys nelsoni (Emydidae). Herpetologica 35:139-145.

Several carapace bones from different individuals were found on Edisto Beach, Colleton County, South Carolina. The nuchal bone of diamondback's are distinctive and are the key morphological feature used to identify the species from fossil remains. These deposits date to the mid-pleistocene, thus the terrapin has been a distinct species for at least 1 million years. The hypothesis that Malaclemys shared a most recent common ancestor with Graptemys was supported, however neither data nor analyses were presented to support this claim.


A survey was conducted by the New York Turtle and Tortoise Society, People for the Ethical Treatment of Animals, and the Center for Environmental Education to identify threats to the diamondback terrapin and to promote its conservation throughout its range. Individuals from a variety of disciplines were questioned by telephone about the population status of terrapins in their areas, the main threats to the populations, the existence of commercial fishing for them, and legislative protection. The information was arranged by state, and contact people were provided for each area. It was noted that the majority of informants had little or no actual numerical data concerning diamondback terrapin populations.


Terrapins from New Jersey and Virginia had blood characteristics different from humans. Total protein, albumin, and bilirubin was lower than in humans, while calcium, blood urea nitrogen, alkaline
phosphate, lactic dehydrogenase and serum glutamic-oxaloacetic transaminase were higher in turtles. Other blood components tested were similar in terrapins and humans.


Dunson investigated the water balance and blood electrolyte levels. Terrapins accumulated blood electrolytes when salt concentration of the water was increased and thus, have a mechanism to remove excess electrolytes when concentrations are reached which are detrimental to the body. The crocodiles used in this study do not have this capacity; they are tolerant to exposure to salt water, but do lose weight.


This review discussed the work on reptilian salt glands which had been completed before 1976. Diamondbacks are a popular subject for salt gland research because they are a estuarine reptile readily available to researchers.


Growth rates were reported for terrapins raised in water with different salinities and also additional injection of salt. Terrapins grew slower in higher concentrations of sea water; terrapins raised in full strength sea water did not grow at all, unless offered fresh water to drink, in which case they grew very slowly. Optimum growth of terrapins was obtained at sea water concentrations of 25%, thus terrapins required a greater amount of salt to obtain maximum growth rates than do freshwater turtles. Costal nesting beaches are near waters with high salinities, however hatchlings must take refuge from the salt in more inland estuaries.


Na-K ATPase activity in the lachrymal and salt glands of terrapins was investigated. Terrapins were exposed to fresh water and 100% sea water for prolonged periods of time. Na-K ATPase activity increased with an increase of Na concentration in the plasma. There was no accompanying increase in the salt gland size with an increase in exposure to salt water. This finding is contrary to avian salt
glands. Terrapins which were exposed to full strength sea water for several months did not reach maximal ATPase production as did those which were injected with additional Na. Thus terrapins are well adapted to variable salt water environments.


Finneran described sightings of the diamondback terrapin in Connecticut in 1948. It was published as an encouragement for the protection of the species in this state to restore population levels. This was the first paper to mention the capture of terrapins in fyke nets.


Osmotic pressure and concentrations of Na, K, and urea were tested in the blood and urine of the terrapin raised in different concentrations of salt water. In 0%-50% sea water the terrapin counteracts osmotic imbalance in the blood by increasing concentrations of Na and Cl, however the imbalance is counteracted by increased ion concentrations in the urea at greater than 50% seawater. Urine of terrapins is isosmotic in sea water, however it becomes hypsomotic in fresh water. The bladder played an integral role in reducing water loss but was not implicated in salt regulation.


Garber described the attempts to establish protective status for the terrapin in New York. He raised a major concern over the increasing demand of terrapin flesh among orientals. New York's Fulton Market sells approximately 10,000 terrapins annually. Among the turtles sold here terrapin is the highest for the apparent superior flavor of the meat compared to other emydid turtles which can be purchased here. The superior quality of terrapin flesh resulted in a demand greater then its supply.


Diamondbacks were acclimated to conditions of fresh water and full strength sea water and the response of various tissues to higher blood osmotic pressure were examined. In muscle tissue, bladder mucosa and jejunum mucosa; urea, amino acids, and ammonia (bladder only) were used to balance osmotic pressure increases in the blood. In the colon mucosa there were large increases in urea and slight increases in amino acids and sodium and chloride.

Terrapins were kept in salt and fresh water for a year and periodic samples of blood were taken and analyzed for ion concentrations. Na, K, and Cl concentrations in the blood were always highest in the sea water treatment. Ion regulation peaks during July and decreases during winter when blood plasma increases in ion concentrations. Data were not provided on the water temperature in which the terrapins were held, so it is impossible to determine if the changes in blood plasma ion concentrations was a function of a physiological change in osmoregulation or a change in reaction rates due to temperature differences for the different months.


This study compared the hematocrit, red blood cell counts, and ion levels in terrapins which were exposed to sea and fresh water for a year. Terrapins in salt water had higher hematocrit and red blood cell counts than those exposed to fresh water. These two variables also showed peaks at the onset and end of the hibernation season. Ion concentrations were similar between the two test groups, however there were slight seasonal variations with Na and Cl levels decreasing and K levels increasing during summer or active season. These results indicated that red blood cell volume and ion content may be controlled independently.


Godley gave a brief species account for the mangrove terrapin which live exclusively in the Florida Keys. Because of its restricted range, this subspecies of terrapin is considered rare. The article provided additional information of the general ecology and limited knowledge of the life history.


Purification of carbonic anhydrase from the erythrocytes from terrapins indicated that two isozymes of this enzyme exist. The low activity enzyme, molecular weight 28,500 daltons was present at about 3-10 times the concentration of the high activity enzyme, molecular weight 30,400 daltons. The paper also discussed the evolution of the
carbonic anhydrase (CA) molecule and its occurrence in vertebrates. It was postulated that the gene for CA underwent a tandem duplication to its present form in mammals and turtles. It was previously believed that this duplication occurred in the mammalian lineage but its presence in turtles suggests that it occurred in a common ancestor of these two lineages.


Hay reviewed the descriptions of the genus Malaclemys. The species was originally described by Schoepff in 1792, however it went through several taxonomic revisions up to the date of this paper. When Hay's paper was published, Schoepff's original naming of the species was not recognized and this resulted in several papers in which the species name is M. centrata. The specific part of the species name is currently recognized as terrapin. A brief review of the natural history of the species and several plates, with a dichotomous key to the subspecific level is also provided.


Facilities and techniques for the breeding and rearing of diamondback terrapins was described. Included were detailed descriptions of the turtles life cycle and advice on the care of hatchlings. The conditions described were somewhat crowded and unsanitary. It was noted that the overwhelming majority of the turtles bred on the farm were female.


This paper described some of the differences between the species of the genus Malaclemys. At the time of publication, the map turtles were considered part of this genus and the paper dealt primarily with them. They are now classified in their own genus, Graptemys. The diamondback was mentioned only once in this paper.


Gunther's short note described the status of various turtle species on the Mississippi coast and mentioned that the terrapin was common in the brackish waters of the Gulf Coast.

Hildebrand reviewed experiments which were conducted at the U.S. Fisheries laboratory in Beaufort, NC. Data were presented on growth rates, optimal sex ratios, fecundity schedules, and other life history parameters of captive terrapins. He also reviewed a series of papers that were published by Hildebrand, Hay, and Coker; these experiments were described in greater detail in other publications. Data of fecundity schedules were incomplete because they did not take into account high levels of predation by rats on eggs during some years.


This study investigated the possibility of hybridizing different subspecies of terrapins in order to obtain a hybrid which would reach a larger market size more quickly. Terrapins from North Carolina were hybridized with terrapins from Texas. The results indicated that the hybrids grew slightly faster and larger than terrapins from North Carolina. However, sex ratios of the hybrids were biased towards males and thus the technique was not productive from an economic standpoint. Texas terrapins seemed to have a reduced quality of meat. The differences in sex ratio observed provided circumstantial evidence that there may be variation among populations of terrapins with regard to environmental sex determination.


Hildebrand described the growth, sex ratio, and longevity of several cohorts of captive diamondbacks raised on a turtle farm in North Carolina. A considerable "headstart" in growth was attained if hatchlings were brought inside and fed for the first winter, however subsequent growth was not different from outdoor raised animals. Female terrapins from North Carolina, frequently did not become greater than six inches in length and males rarely got above four inches in length. This contrasted with terrapins from Texas which attained a size of eight inches for females. Hildebrand observed a female-biased sex ratio (5.9:1) of captive bred individuals and recognized that this was a perplexing problem which warranted further research. Finally, he estimated longevity of this species to be greater than 40 years old, based on counting of annuli of known aged individuals and comparing the results with those of unknown aged individuals.


This was a more detailed revision of Hay and Aler's 1917 circular "Artificial Propagation of the Diamondback Terrapin." It also added a description of a suggested "hibernating box" for young terrapins, and discussed winter feeding experiments in which young
terrapins were prevented from hibernating through housing in a heated building.


A two year study was conducted in a Delaware salt marsh which gave an estimate of the terrapin population size. Turtles were captured during the summers of 1975 and 1976 using primarily an otter trawl. The Lincoln population index, based on mark recapture data and size class distributions of captured animals, was presented. They obtained highest capture rates during June; animals dispersed in the later summer months, reducing capture success during these times. They found no evidence of recruitment between years but also were unsuccessful in capturing juvenile terrapins, thus their evidence is inconclusive.


The authors described the presence of two molluscan parasites on the carapace of a single female ornate diamondback terrapin. The parasites found on this individual were the oyster, Crassostrea virginica, and a slipper shell, Crepidula plana. These are not common parasites on this species and it was suggested that basking and shedding of scutes usually removes these parasites. It was also suggested that this type of parasitism may make terrapins more vulnerable to predators, through decreased mobility, and may obstruct their copulation.


Jackson described the fouling of a terrapin shell by a barnacle which had subsequently died. The remains of the barnacle were used as a substrate for attachment of the bivalve mollusk, Brachidontes exustus. Although the terrapin's shell is an unsuitable substrate for this mollusk, the previous settling by a barnacle provided a suitable substrate. It was suggested that settling on movable substrates might be beneficial for benthic invertebrates because it provides for increased circulation of water.


This educational leaflet distributed by the Baltimore Aquarium dedicated this issue to the diamondback terrapin. The natural history
reported herein is information which has been gained from the population currently under study in the Patuxent Estuary. Additionally, aspects of the terrapins history and basic biology are discussed.


Johnson's brief note described the range expansion of M. t. rhizophorarum on the west coast of Florida. A single specimen was captured in northern Florida which had characteristics of this more southern subspecies.


The authors described the hibernation of a single juvenile terrapin in Gloucester point, Virginia. The turtle emerged and began its hibernation in the sand on 7 November and returned to the water on 23 April. The terrapin did not move from this location or grow over this period, nor did it lose any weight.


A search was organized by Peter J. Auger for nesting terrapins in the dunes at Sandy Neck, Massachusetts, where they were abundant half a century ago. The few turtles found catalyzed the formation of the Sandy Neck Ecology Project. Unique aspects of nesting behavior in the Massachusetts Bay were described, notably the fact that nesting times in the bay were independent of high tides. The temperature of the nests and of open sand were monitored with portable telethermometers over the winter. Nesting sites were significantly warmer than the rest of the dunes.


This short note described the predation of terrapin eggs by dune grass. Eggs in nests laid in proximity to dune grass were frequently surrounded by grass rootlets and killed. It was not known, however, if the grass preyed on infertile eggs or fertile eggs. The grass destroyed individual eggs within a nest and also entire nests. The authors suggested that nest site selection of terrapins is influenced by this phenomenon.

The characteristics of nests of terrapins were presented and a series or correlation analysis was made to determine how characteristics were related. Positive correlations were found between egg length and width, clutch mass and weight, and plastron length and clutch mass and size. No correlations were found between egg size and egg dimensions or nest dimensions. The mean clutch size was 9.76 and the mode was 10 eggs. Mean female length of females caught ashore was 154.4 mm. Finally, during the nesting season, mean egg size decreased. These results were compared with the literature of avian reproductive biology.


Palmer and Cordes provided one of the best literature reviews of the diamondback terrapin to date. They reviewed the available natural history and life history data for this species. Based on the data available from the literature, they suggested criteria to identify suitable habitats for nesting terrapins. They identified three properties of nesting beaches which are essential for terrapin nesting: 1) percent canopy over the nesting area, 2) percent vegetation, and 3) the slope of the nesting area. These three factors can be readily determined for an area, then the suitability of that area can be evaluated using a linear combination of the independent indices. Caution should be taken in applying the model, since it is simplistic and does not take into account other factors which may affect nest success.


This brief note described the capture of juvenile terrapins, which had been difficult to catch before the method used here was developed. Pilter described their capture several meters inland from the water’s edge under surface debris on a tidal mudflat. The Spartina mat and various forms of debris seem to provide cover for juveniles.


This brief note described the nesting activity of a single terrapin near Yorktown, Virginia. Subsequent to the nesting, the eggs were removed and incubated at room temperature. One of the six eggs was opened 34 days into incubation, four of the remaining five hatched. Size data were presented for the hatchlings and the embryo. Photos of the hatchlings were also presented.

The authors investigated the composition of 21 terrapin eggs from 7 clutches. Terrapins eggs from this New Jersey population were 68.9% water and 8.2% lipid. The average energy content of eggs was 6.88 kcal/g dry weight. Lipid content of eggs did not increase with egg wet weight, however water content did increase. This finding indicates that increasing egg size does not necessarily increase energy available to developing embryos.


This study reported on water and sodium balance in terrapins. Terrapins acclimated to salt water lose water; this water loss is primarily extracellular and not intracellular. Terrapins in salt water can restore extracellular water through drinking freshwater. The principle method of water exchange was through the integument and the principle means of sodium uptake was orally. Sodium was excreted primarily through the ocular salt gland and secondarily through the cloaca. The skin was impermeable to sodium.


The fouling of a terrapin collected in Florida was described. The turtle's shell was fouled with barnacles, Balanus improvisus, two oysters, Crassostrea virginica, and a gastropod, Crepidula plana. A detailed description of the parasitism was given and it was noted that this phenomenon was not common to all terrapins captured in this area.


This brief article was the first to identify the terrapin's capacity to excrete salt at concentrations higher than its surrounding environment. This capacity is an adaptation to living in estuarine environments. Glands associated with salt secretion are located in the head behind the eye. When terrapins and marine turtles are removed from the water for long periods of time, they appear to be crying. This point has been used in the past as the subject of writings by such popular authors as Lewis Carroll and Rudyard Kipling.

A new subspecies of terrapin from Florida was described in this paper and was named *Malaclemys terrapin tequesta*. This subspecies is distinguished from the other three subspecies of terrapins in Florida by its size, external markings, and geographic range.


Seigel report the finding of eight dead diamondback terrapins for which the cause of death is unknown. All the turtles were in a small, 35 meter, area of beach and were males. It was suggested that the turtles were forced ashore by rough weather and then died from desiccation.


Seigel described the predation of adult terrapins by raccoons in a nesting area on Merritt Island National Wildlife Refuge, Brevard County, Florida. He estimated that raccoons kill at least 10% of the adult females when they come ashore to nest and that this was the major source of mortality for the size class in his population. He suggested that the unusually high predation rate of females may be a consequence of the destruction of primary nesting sites; because of habitat alteration nesting females are forced to oviposit in areas where they are more vulnerable to predation.


Seigel presented data on the reproductive biology of a population of terrapins in Florida and compared the results to those of other studies conducted throughout the species' range. Terrapins in Florida laid smaller clutches with larger eggs than do conspecific individuals farther north. As a result, hatchlings were larger than those of the northern subspecies. There was a significant relationship between female plastron length ("pl") and clutch size, but not between "pl" and egg size. Behavioral data was also provided describing terrapin nesting. They preferred to nest on clear sunny days with ambient temperature above 24°C, and most nesting occurred at temperatures above 28°C between the hours of 1040 - 1610. Findings of this study were consistent with predictions that turtles in warmer regions should lay smaller clutches with larger eggs.


This brief note described the mating behavior of a terrapin
population in Florida. Matings were observed in March, between the hours of 1040 and 1610. Water temperature ranged from 24.8 and 27.0°C. All matings took place in the water. Typically the male approached a female from behind and nudged her cloaca with his nose, if the female did not swim away he mounted her. Copulation then took place, lasting approximately two minutes.


Two populations of terrapins from central Florida were compared for the amount of infestation by barnacles. Three species of barnacles were observed on terrapins: Balanus eburneus, Chelonibia testudinaria and C. manati. A significant difference in the amount of infestation by barnacles was observed. Two explanations were offered for the observed differences: 1) differences between the salinity of the water of the two populations might affect rates of infestation by barnacles, or 2) limited numbers of basking sites may prevent sufficient basking time to desiccate and kill the barnacles. Infestation by barnacles in one of the two populations was observed to be extremely heavy, with some individuals having a 3 cm deep layer of barnacles. This amount of infestation was observed to adversely affect nesting behavior, including the female's ability to make an adequate nest. Two cases of mortality possibly induced by barnacles were described; although the cause of death was not certain, barnacles appeared to have contributed.


Populations parameters were given for two populations of terrapins from Florida and were compared to other populations which have been studied. Data were given for growth rates, age and size of maturity, population age and size structure, and population size estimates. Only population size-class structure was found to be different between these two populations. The following life history data were reported for this population; age of maturity is 4-5 for females and 2-3 for males, size of maturity is 140 mm for females and 95 mm for males. A 5:1 female biased sex ratio was reported, however no test for biases in capture techniques was made. The difference in population structure between the two populations was attributed in different predation rates by raccoons on nesting females. Population estimates were calculated using the Schnabel techniques and estimated population sizes of 405 and 213 for the two site; these estimates, however, had large confidence intervals because of low recapture rates.

This article described the history and natural history of the diamondback terrapin in New York State. No quantitative data were presented, but descriptions of nesting, foraging, mating, and activity periods are provided.


Ammophila breviligulata, a common beach grass in sandy dune areas, has the ability to absorb nutrient exudates from terrapin eggs. Radioactively labeled nutrients were injected into terrapin eggs, and then were planted in flower pots with beach grass. Nutrients were absorbed by the plants, peaking after about 100 days of incubation. Roots from the plants entangled the egg, with an increase in growth by enhanced root branching in the area of the egg. The availability of terrapin eggs is probably of little significance to beach grass populations, however the grass may be a significant predator of terrapin eggs.


Woods briefly described the life history of diamondback terrapins and the effects that hunting has had on the populations. The characteristics of New Jersey's terrapins are emphasized, and a summary of the state's protective legislation for them is included.


Wood hypothesized the evolution of the genus Graptemys from the Malaclemys based on evidence of distribution, physiology, and morphology. This hypothesis suggests that several independent evolutionary events gave rise to the map turtles from terrapins, and implies that the map turtles are a polyphyletic group. Thus the currently held classification of the Graptemys-Malaclemys group is incorrect based on Wood's analysis.


Roger Wood searched the Florida Keys for mangrove terrapins in order to locate and assess the abundance of mangrove terrapin populations, to discover basic information about their natural history, and to determine more precisely the distinctive characteristics of the subspecies. Three hundred mangrove terrapins were found and were marked, measured, and sexed. Air, ground, water,
and body temperatures were recorded, as well as the salinity of the water. Some striking aspects of the mangrove terrapin were that it was occasionally found in pools which were twice as salty as the nearby ocean water, and that mangrove terrapins do not hibernate.


This paper described methods which were used by terrapins as hibernating techniques. They were: 1) resting on the bottom under water, 2) burying atop creek banks, and 3) taking refuge beneath undercut banks. Terrapins had little or no mortality during this time. Dates of hibernation were not provided.
The following articles involve terrapins, but efforts to locate these articles have been unsuccessful because of either their age or the obscurity of the journal in which they were published.


FIELD GUIDES AND NATURAL HISTORY


Babcock's treatise of the turtles of New England gives a detailed description of the diamondback and provides information on natural history and commercial background of the species. At the time of this publication the terrapin was one of the best studied turtle species because of its commercial value.


This is probably the best field guide currently available and includes a description of the terrapin along with color photos. The guide is solely for identification and provides little additional information.

This popular field guide provides color plates, as well as a thorough description of the diamondback. A range map is included showing the entire distribution of the species. Conant recognized seven subspecies of diamondback's based primarily on geographic range.


This book gives a description of the species, which provides several photos and discusses geographic variation, behavior, reproduction, growth, and foraging behavior, as well as other natural history aspects.


A general description of terrapins is given and the individual subspecies are given their own sections. Beware of the outdated taxonomy used in this text. There is also a limited amount of natural history data in this book.


This field guide to the turtles of Maryland includes the diamondback terrapin. It provides a picture and range map of the terrapin for the State of Maryland. Dr. Schwartz gave a brief description of terrapins and provided some notes on natural history. Caution should be used for the natural history data, since it is scanty and much of it seems to be inaccurate for populations of terrapins in the Chesapeake Bay. Page 10 of this publication presents a table which reflects the economic contribution of the terrapin fishery to Maryland watermen during 1957-58. The text also discusses the economic contribution of terrapins in past years.


This is a useful field guide for identification of preserved specimens because it contains a dichotomous key which includes characters other than color patterns.
DISCUSSION

The diamondback terrapin, *Malaclemys terrapin*, is an immensely popular symbol for the state of Maryland. The project has provided some preliminary results of a continuing effort to better understand the history, biology, and economic aspects of this species. Detailed investigation of the life history of this organism indicates that it may be extremely vulnerable to mismanagement. The near extermination of the species at the turn of the century illustrates the potential disaster of heavy fishing mortality. However, it is a commercial species and some watermen in the Bay area are dependent upon this species for their seasonal livelihood. A compromise is needed to protect both the interests of terrapins and the watermen.

The following recommendations are based on current knowledge of the terrapin's life history and the commercial market place. It is recommended that Maryland establish a discrete fishing season for terrapins which will exclude those months of the year when nesting is occurring. An exclusive winter fishery is recommended which could start in October and through March. Other states throughout the terrapins range have taken similar measures to regulate the fishery. This schedule also would eliminate the problem of incidental or by-catch use of terrapins by those watermen who target other species, but keep terrapin for extra cash. In addition, tighter regulations are proposed concerning the gear which can be used to collect terrapin. Prohibiting watermen from using fyke nets, pounds, and bank traps to
harvest terrapin unless they have a specific license to do so may reduce the by-catch problem. This problem could also be partially regulated through a limited fishing season. Several states throughout the species range have imposed restrictions on both the season and the type of gear which can be used to capture terrapins.

Also recommended is a change in the size restrictions concerning terrapins. An upper limit to protect some of the reproductive females, which currently are the only individuals that reach legal size, may help in sustaining natural populations. Before a size regulation can be implemented a thorough investigation of body size variation needs to be conducted. Conversations with watermen have indicated that terrapins in higher salinity areas such as Chincoteague Bay are much smaller in size. This protection could be accompanied with a decrease in minimum size to allow for the harvest of male terrapins, however the latter aspect remains problematic since males are not as popular as females for consumption and crab pot mortality remains uncertain.

Perhaps the greatest hope for terrapins as a commercial species lies in mariculture. Given the appropriate conditions, terrapins can grow rapidly and reach a marketable size within four years. Terrapin eggs are easy to collect and incubate and environmental sex determination makes it possible to produce only females, the desired commercial sex. Mariculture eggs might have the least impact on populations since the survivorship in the wild during this stage of
life is low. Terrapins nests are easy to locate within 24 hours of oviposition, after 24 hrs, nest are no longer distinguishable and have an increased chance of survivorship in natural environments. If the demand for terrapin increases and the price continues to increase, mariculture may well become a viable alternative to increasing fishing pressures on natural populations.

Current plans are to continue investigation of the terrapin's life history and its commercial fishery. Research will concentrate on those population-level processes which affect terrapins the most. Currently, studies on environmental sex determination and how it effects populations are continuing. A thorough understanding of the biology of terrapins and good data based management strategy will enable Maryland to adopt an exemplary management program for this long- lived vertebrate, the diamondback terrapin.
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